Lunar Regolith Particle Shape Analysis

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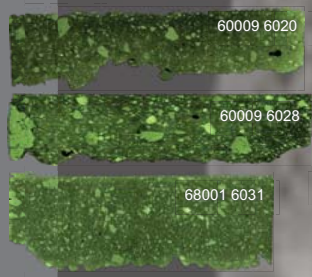
Abstract

Future engineering of structures and equipment on the lunar surface requires significant understanding of particle characteristics of the lunar regolith. Nearly all sediment characteristics are influenced by particle shape; therefore a method of quantifying particle shape is useful both in lunar and terrestrial applications. We have created a method to quantify particle shape, specifically for lunar regolith, using image processing. Photomicrographs of thin sections of lunar core material were obtained under reflected light. Three photomicrographs were analyzed using ImageJ and MATLAB. From the image analysis measurements for area, perimeter, Feret diameter, orthogonal Feret diameter, Heywood factor, aspect ratio, sieve diameter, and sieve number were recorded. Probability distribution functions were created from the measurements of Heywood factor and aspect ratio.

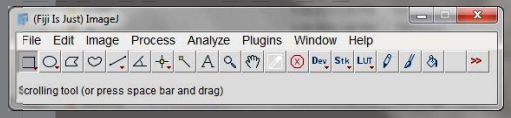
Introduction

Shape is an important characteristic of sediment because it influences many other properties. Defining particle shape is complex and a standard method does not exist. In the case of lunar regolith, there is only a small amount of information available on particle shapes. In order to obtain a large and accurate dataset of lunar regolith particle shape, we aim to create a method that provides a quick, effective way to compile shape data.



Three polished thin sections under reflected light, from Apollo 16 program double drive tubes. The green color is an effect of the photography, the sections are actually gray and black.

Shape can be characterized by aspect ratio and Heywood factor. Aspect ratio is a function of Feret diameter and orthogonal Feret diameter; which are the longest distance between two edges and the longest distance between two edges which is perpendicular to the Feret diameter. Heywood factor is a function of perimeter and area. Historically, these measurements have been done by hand or with an apparatus that measures one particular measurement. An example is a sieve. Sediment is passed through a set of screens that decrease in mesh size from top to bottom in order to determine the grain size.



Using ImageJ and MATLAB software, we have created a method to produce these measurements for over 50,000 particles within the three lunar thin sections above.

References

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[6] Mauer, C. 2D Hybrid Median Filter, 2007, http://rsbweb.nih.gov/ij/plugins/hybrid2dmedian.html
[7] Boudier, T. Hysteresis Thresholding, 2012. http://imagejdocu.tudor.lu/doku.php?id=plugin:segmentation:hysteresis_thresholding:start
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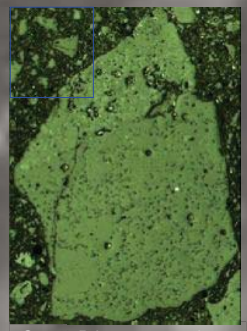
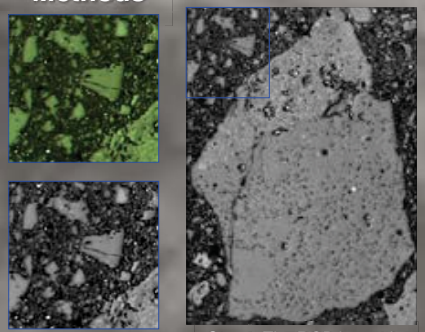
Goals

- Present a documented method for measuring lunar regolith particle shape from a thin section.
- Collect lunar regolith particle shape data.

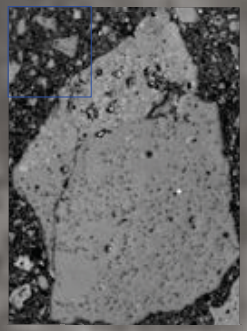
Methods



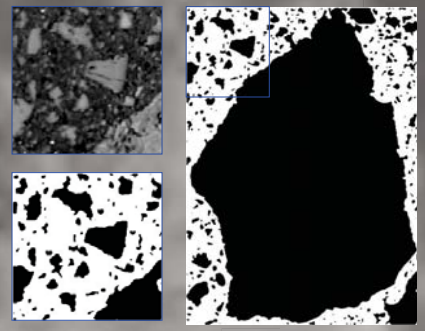
Step 1. Prior to processing, the image is an RGB TIFF. Shown is a small area of the 60009 6020 thin section.



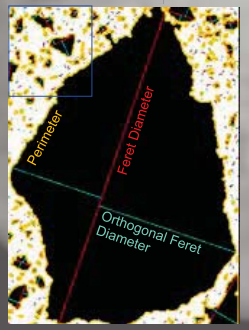
Step 2. The RGB image is split into the red, green and blue channels. The green channel is used for processing.

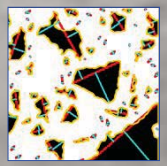


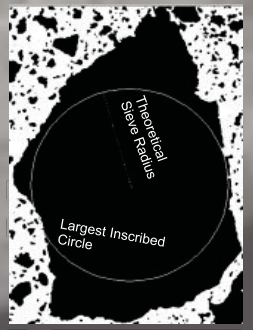
Step 3. In order to minimize noise within the image, a median filter is applied via the Hybrid 2D Median Filter plugin.



Step 4. Hysteresis thresholding converts the greyscale image into a binary image so individual particles can be measured.





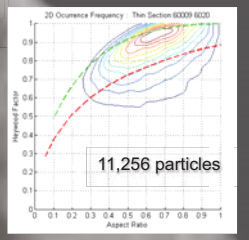


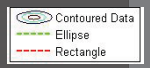
Step 5. The area, perimeter, Feret diameter, orthogonal Feret diameter, and theoretical sieve diameter are measured for each particle.

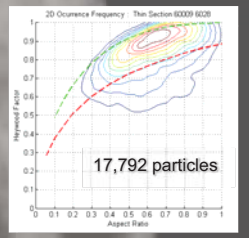
Measurements

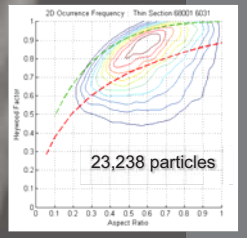
Particles with areas greater than 100 pixels were measured in ImageJ, yielding a total of 52,286 measured particles between the three thin sections.

2D frequency distributions of the measured Heywood factor and aspect ratios were generated in MATLAB for each of the three thin sections, based on the obtained data.









Conclusion

We created an automated method capable of measuring lunar regolith particle shape from thin sections. This method measured approximately 52, 000 particles. The distributions show that all three thin sections have similar shape frequencies, which is likely due to the close proximity from which the samples were taken and the process which created the regolith. These data will allow us to quantify the similarity of the sample's shapes. Future analyses that can be built off of this method include determining relationships between particle shape, composition, size, orientation, and spacing. For future applications of this technology, better adjustment of the illumination is recommended; and a technique to mend cracked particles should be developed.

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